Modeling the U.S. Military Intelligence Process

Dr. J.O. Miller
Department of Operational Sciences
Graduate School of Engineering and Management
Air Force Institute of Technology
2950 Hobson Way
Wright-Patterson AFB, OH 45433
Voice: 937-255-6565 x4326; Fax: 937-656-4948
John.Miller@afit.edu

Capt Carl R. Pawling, USAF
ACC/DRYF
Langley AFB, VA 23665
Voice: 757-764-2069; Fax: 757-764-7217
Carl.Pawling@langley.af.mil

Maj Stephen P. Chambal, Ph.D.
Studies & Analyses Group
NRO DDSE, 4GB18C
14675 Lee Road
Chantilly, VA 20151-1715
Voice: (703)808-3211; Fax: (703)808-1310
Stephen.Chambal@nro.mil

		Form Approved OMB No. 0704-0188
Report Documentation Page	

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE **SEP 2004**	2. REPORT TYPE	3. DATES COVERED **00-00-2004 to 00-00-2004**
4. TITLE AND SUBTITLE **Modeling the U.S. Military Intelligence Process**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air Force Institute of Technology,Department of Operational Sciences,2950 Hobson Way,Wright Patterson AFB,OH,45433**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **The original document contains color images.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES **32**	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**			

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Abstract

Military use of the intelligence process is vital both in and of itself and as a valuable input to our Command and Control, enhancing military power through information superiority. The intelligence process begins when a need for information or intelligence is identified and encompasses how these information needs are met. As such, this process includes all of the satellites, aircraft, and communications systems used to gather and transmit data as well as the people, organizations, and resources involved in turning raw data into useful information. To support current and future Intelligence, Surveillance, and Reconnaissance (ISR) systems more detailed analysis of the intelligence process becomes critical to determine what pieces may need to be improved or expanded. Our approach involves construction of a modularized top level computer simulation model of a generalized military intelligence process using the *Arena* process oriented simulation software. The model provides the ability to perform quick turn analysis for comparing structural modifications to the intelligence process using typical measures of performance (quality, quantity, timeliness, and information needs satisfaction). The study also includes a statistical analysis of various configurations of this intelligence process.

Introduction

The importance of assessing the information flow of the military intelligence process has been brought to light in recent years. Although, the need for this assessment is not new, it becomes more critical as both capability and demand increases. According to the National Security Strategy, "We must transform our intelligence capabilities and build new ones to keep pace with" terrorist and other threats [White House, 2002:30]. The intelligence process begins when a need for information or intelligence is identified and encompasses how these information needs are met. As such, it includes all of the satellites, aircraft, communications, and other systems used to gather and transmit data as well as the people, organizations, and resources involved in turning raw data into useful information. The intelligence process can take on many forms, two of which are Task, Process, Exploit, Disseminate (TPED) and Task, Process, Post, Use (TPPU).

To illustrate the TPED and TPPU processes, take for example a person with a standard 35mm camera, lets call him Bob. The need for information about a particular place has arisen. Once this need is realized and it is determined that a picture can satisfy the need, Bob is directed or *tasked* to go take a picture of this place. Once Bob has taken the picture and returned, the picture is still of no use. A series of steps must be taken to put the picture into a usable form. Specifically the picture must be developed or *processed*. Now that the image is in a usable form, the remainder of the intelligence process can be carried out in several ways. For the TPED approach, an analyst would take additional steps to *exploit* the picture. These steps might include marking important aspects of the image and adding notes to describe what those aspects are. Once this is complete, the picture with the markings and additional information would be sent out or *disseminated* to the person or organization that needed the picture. Alternatively, the TPPU approach would bypass the exploitation up front and send or *post* the picture to a web page. Then the person or organization that needed the picture could retrieve it and use it without the overhead of exploitation. Although this is a simplified example, it illustrates how TPED and

TPPU can differ. In reality, the intelligence process is more complex and is dependent on several systems, organizations, and user requirements.

In developing a simulation model of this intelligence process the researcher needs to ensure that the model is structured for specific measures of interest. Those measures should provide the required information for the intended uses of the model. Four measures of interest for analyzing the intelligence process are quality, quantity, timeliness, and information needs satisfaction (QQTI). The first three measures; quality, quantity, and timeliness (QQT), have historically been used when assessing various aspects of the intelligence process. As such previous models may be designed to provide those quantitative measures for a specific implementation of the intelligence process. Where applicable some of the concepts in these models may be used in model development. More importantly examination of open source and unclassified descriptions of the intelligence process provide the primary source for model development. In addition to basic descriptions, factors that influence the process and consequently the QQTI measures are taken into account based on subject matter expert (SME) discussions. The use of *Arena* to model the military intelligence process in a modularized design allows the fidelity of individual portions of the model to be easily expanded for future simulation studies.

Construction of a simulation model of the intelligence process requires a number of simplifying assumptions that dictate the level of abstraction of the model from the real world. Based on the intended uses of our model, a moderate level of detail should be sufficient for this initial study. Comparing the impact of changes to various portions of the intelligence process for quick look studies does not require the detail of engineering level models. Furthermore, the moderate level of detail extends to all portions of the intelligence process model including an embedded communications model. By maintaining the focus of building a top level framework for simulation studies, only open source and unclassified information are required to develop the structure of the model.

The remainder of this paper provides a brief discussion of the intelligence process and some previous work in modeling and assessing this process. We then provide more detail on the development of our *Arena* model of a generalized intelligence process. The paper continues with a discussion of our model input data and an analysis of some baseline results. We conclude with some insights and conclusions based on this study and recommendations for further efforts. A much more detailed presentation of this study can be found in Pawling [2004].

Background

The intelligence process used for this study is described in Joint Publication 2-0, *Doctrine for Intelligence Support to Joint Operations*, as the intelligence cycle. The intelligence cycle has six phases shown in Figure 1. These phases are Planning and Direction, Collection, Processing and Exploitation, Analysis and Production, Dissemination and Integration, and Mission Evaluation and Feedback. Planning and Direction involves planning for future contingencies in theaters and determining what resources might be required for those contingencies. Existing information and previously scheduled information gathering is used when possible, but the remaining information requirements are turned into requests for information (RFIs) which can lead to either production
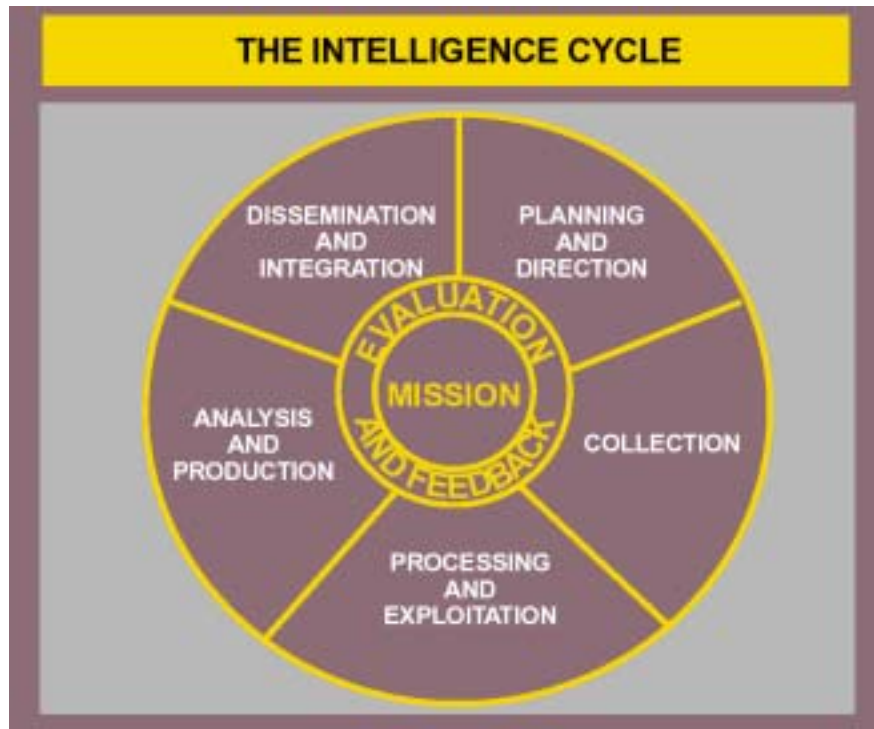
Figure 1. The Intelligence Cycle [JP 2-0, 2000:II-1]

or collection requirements [JP 2-0. 2000:II-4]. The second phase, Collection, carries out the plan for the gathering of information. In this phase, organizations or agencies that operate collection assets such as satellites or surveillance equipment task those assets to gather information at specified times and places. The means and methods of collection are highly dependent on the source of the information and these sources are generally categorized into various intelligence disciplines.

After Collection, the Processing and Exploitation phase takes the raw data gathered and transforms it so that it can be used for analysis and production [JP 2-0, 2000:II-7]. The amount and type of work involved depends on the type of intelligence that has been gathered. Analysis and Production uses processed and/or exploited information to generate intelligence products to meet the RFIs.   The intelligence products are usually categorized by their primary use: indications and warning, current intelligence, general military intelligence, target intelligence, scientific and technical intelligence, and counterintelligence [JP 2-0, 2000:II-10-12].   These categories may overlap and are not confined to any particular source of intelligence. Dissemination and Integration involves sending intelligence products to the user and the user incorporating these products into their efforts [JP 2-0, 2000:II-12]. This phase of the intelligence cycle is heavily dependent on communications systems due to the likelihood of significant geographic separation between the intelligence production center and the user.   The dissemination of information can be either "pushed" to the user to answer a request or "pulled" by the user from databases and other centralized sources of information.

The final phase, Mission Evaluation and Feedback, is integral to all of the other phases and is appropriately placed in the center of Figure 1. It is not conducted independently but must be accomplished throughout each phase to ensure that the process is working as expected. Qualitative attributes that are used to evaluate the quality of intelligence are timeliness, accuracy, usability, completeness, relevance, objectiveness, and availability [JP 2-0, 2000:II-14]. Of these, timeliness can be easily quantified by comparing the time of delivery with the time of need. The other attributes may be difficult to quantify, but they are nonetheless vital when evaluating the overall quality of intelligence. In addition to these individual measures, a single aggregated measure can be defined. One example is information needs satisfaction (INS). Although this measure can be viewed as the process of meeting information needs, as a measure it can describe either the proportion of needs that are met or the degree to which needs are met. When specifically related to QQT, INS would simply be the proportion of intelligence requests that meet both of the quality and timeliness requirements. Alternatively, INS could be rated on a scale with items that meet both of the quality and timeliness requirements at the top with decreasing scores based on how poor or how late the response to a request was received.

Before constructing our simulation model of the intelligence process, we conducted a review of previous simulation studies and existing models. The models reviewed ranged from high fidelity to low fidelity and implemented either a single architecture or multiple architectures. For a more detailed discussion on specific models reviewed, see Chapter 2 of Pawling [2004]. For quick look studies a low fidelity or high level model that describes multiple implementations is ideal. The Quick ISR Concept of Operations Modeler (QUICM) comes closest of the models examined to meeting the needs of our analysis [Kanewske, 2003]. However, QUICM is limited in only allowing two very structured architectural implementations of the intelligence process. The ability to model hybrid implementations allows for a better representation of reality and analysis of transitional stages between complete TPED or TPPU implementations. For example, such a transitional stage might be altering the process for one type of information or for a specific user and examining the impact of the overall system. Rather than modifying one of these existing models we decided to develop our own tailored model of the intelligence cycle.

Methodology

The Intelligence Process Model (IPM) consists of seven *Arena* submodels, six of which are taken directly from the intelligence cycle shown in Figure 1. The last submodel is named Communications and contains the logic to tie together the other submodels. The entity modeled in the IPM represents an RFI. These entities are related to real world RFIs, but they are not exactly the same. RFIs in the IPM are only gathered from a single information source. As such the simulated RFIs more closely resemble a tracking sheet that follows a real information request through the process. The rationale for choosing this abstraction is that assessment of the intelligence process at the top level does not require actual information, only the status of the requests. As the RFIs flow through the IPM a number of attributes keep track of each entity's specific request characteristics and requirements and the associated timeliness and information quality as these are updated throughout the model. These attributes provide the data used in the generation of statistics to evaluate the measures of performance. Figure 2 provides the top level view of the IPM. This modular approach allows any submodel to be easily modified or replaced
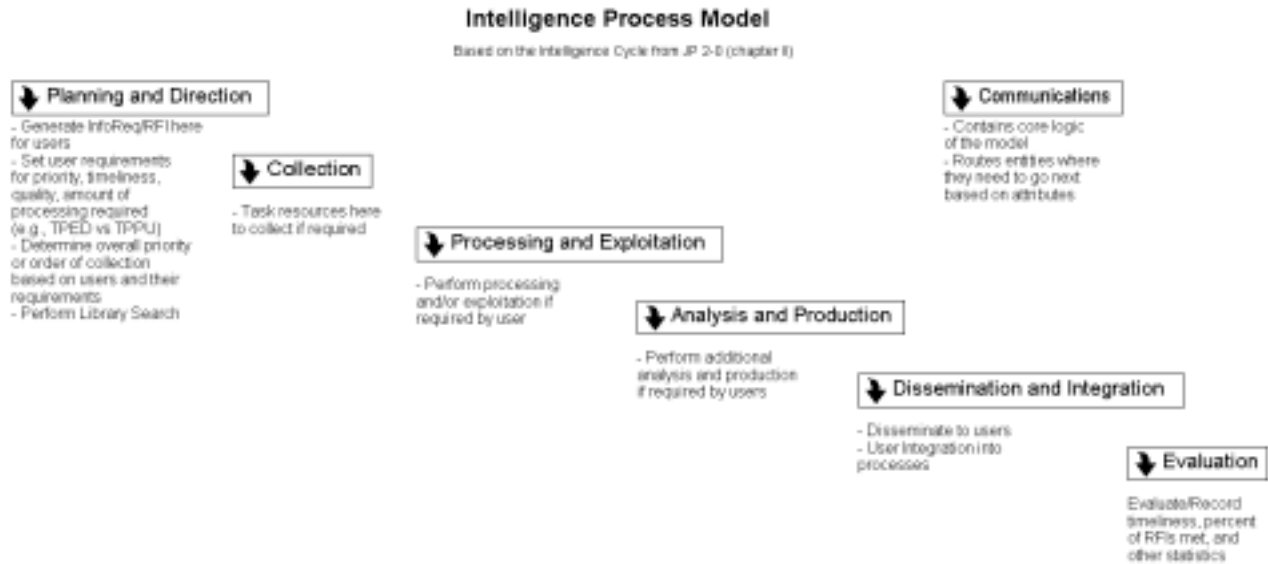
Intelligence Process Model

Based on the Intelligence Cycle from JP 2-0 (chapter II)

Planning and Direction
- Generate InfoReq/RFI here for users
- Set user requirements for priority, timeliness, quality, amount of processing required (e.g., TPED vs TPPU)
- Determine overall priority or order of collection based on users and their requirements
- Perform Library Search

Collection
- Task resources here to collect if required

Processing and Exploitation
- Perform processing and/or exploitation if required by user

Analysis and Production
- Perform additional analysis and production if required by users

Communications
- Contains core logic of the model
- Routes entities where they need to go next based on attributes

Dissemination and Integration
- Disseminate to users
- User Integration into processes

Evaluation
Evaluate/Record timeliness, percent of RFIs met, and other statistics

Figure 2. IPM Top Level View

and keeps the various portions of the process distinct. Each of the submodels is briefly described in the following paragraphs.

The *Planning and Direction* submodel indicates the beginning of the intelligence process and corresponds directly with the process of the same name from the intelligence cycle. The purpose of this submodel is to generate user information requirements and prioritize them globally. As an additional part of the planning process, users perform a library search to determine if existing information may meet their needs. This submodel consists of five separate user requirement submodels representing different generic intelligence users. Each of these submodels generates standing requirements (RFIs) and additional requirements (RFIs) according to input parameters selected. Each RFI is also assigned attributes that determine which of the remaining submodels it is required to pass through as it leaves. This allows the IPM to capture a TPED like architecture (all steps of the intelligence cycle carried out) or different implementations of a TPPU hybrid with some selected steps left out.

The *Collection* submodel corresponds directly to the collection phase of the intelligence cycle. This submodel simulates collection from various sources and determines the quality of the information collected. When arriving to this submodel RFIs are placed into a ranked queue based on their priority attribute until an appropriate collection resource becomes available for use. Upon leaving the queue each RFI is immediately checked for timeliness. If the RFI fails this check it is immediately discarded from the simulation and the next RFI in the queue is assigned the available collection resource. A similar timeliness check is included in all the remaining submodels. From here the RFI undergoes a delay based on its associated required quality and information source attributes. This delay represents the time taken to collect information and is taken from an array of expressions (discrete value, draw from a random probability distribution, mathematical function, etc.) indexed on the value of these attributes.

After completing the delay the RFI is assigned a value (based upon input parameters) representing the actual quality of information collected.

The *Processing and Exploitation* submodel contains an independent set of logic for processing and for exploitation, allowing RFIs to proceed through either or both of these processes. In the processing portion RFIs wait in a ranked queue based on priority for an appropriate processing resource identified by the RFIs information source attribute. The RFI then undergoes a delay based upon the information source and quality attributes. In the exploitation portion various information specialists (different *Arena* resources) are seized to represent the exploitation of the information represented by each RFI and to determine the effect on the information quality. RFIs wait for appropriate exploitation resources in another ranked queue based on priority. The exploitation delay is determined based upon attributes defining the RFI's information source and the required and actual information quality.

The *Analysis and Production* submodel consists of two separate sets of logic to allow RFIs to proceed through either or both of these processes. The analysis portion of the model is logically structured like processing and exploitation. Resources in this submodel represent analysts that can handle RFIs from any information source (all source analysts) or analyst assigned to only process RFIs from one of the available thirteen information sources. As in previous submodels RFIs wait in a ranked queue based on priority. The appropriate delay for analysis is determined based upon attributes defining the RFI's information source and the required and actual information quality. After the delay, the assessed effect of analysis on actual information quality is used to update the actual quality attribute. In the production portion of this submodel RFIs wait in a ranked queue based on priority for an appropriate resource as defined for the analysis process. As in the analysis logic, the appropriate delay for production is determined based upon attributes defining the RFI's information source and the required and actual information quality. After the delay, the assessed effect of production on actual information quality is used to update the actual quality attribute.

The *Dissemination and Integration* submodel consist of two separate sets of logic to allow RFIs to proceed through either or both of these processes. The dissemination portion of this model reflects the user process of acquiring information that has been through some portion of the intelligence process. RFIs wait in a ranked queue based on user priority for a resource from a set of user analysts. The appropriate delay for dissemination is determined based upon the user type. After the delay, the assessed effect of the dissemination on actual information quality based on the information source is used to update the actual quality attribute. Integration in this context refers to the individual users integrating information into their processes, not information integration as related to exploitation or analysis. If this portion of the model is not used, then timeliness is determined by when a user receives requested information. If this portion of the model is used, then timeliness includes a delay to account for user integration. RFIs wait in a ranked queue based on user priority for a resource from a set of user analysts. The appropriate delay for integration is determined based upon the user type. After the delay, the assessed effect of the integration on actual information quality based on the information source is used to update the actual quality attribute.

In addition to these five submodels mimicking the outer intelligence cycle, the *Communications* submodel routes all RFIs between the other submodels and provides appropriate communication delays and resources. The *Evaluation* submodel collects RFI and system statistics. The primary measures of performance for our system are once again quality, quantity, timeliness, and information needs satisfaction (where INS is defined in our context as meeting both quality and timeliness). Upon examination of the raw data for any of these measures, it becomes clear that a composite measure of some type would be more useful than a measure such as the average information quality. In addition, a simple count of the number of requests that are processed provides limited insight. To address these issues we combine the quantity of requests with the other measures to come up proportions of the requests that meet defined quality and/or timeliness requirements. The use of these proportions allows clear comparisons between competing system configurations. Grouping these proportions into various categories, such as by user type or information source, also provides additional insight into the system performance. The following section briefing describes the input data requirements for the IPM and presents results and analysis using these measures of system performance.

Analysis

Before performing a simulation study with the IPM we clearly need to populate our model with data. Even in a high level model such as the IPM the amount of data required to characterize the system is extensive. The data required can be divided into the following basic categories: processing times, resources, effects on quality, and request properties. Everywhere in the model that a delay occurs a resource is required. In addition each time an RFI passes through some simulated process an update is made to the actual quality. The request properties are used to determine when and what type of RFIs are generated. For a complete listing of the required data for a simulation study see Pawling [2004]. As designed with a maximum of five users, thirteen information sources, and thirteen analyst specialties, there are over 2700 data entries available. Real world data needed to populate the IPM was not available due to its sensitivity and classification. So notional data was generated as a baseline for comparative study. For our sample study 830 data entries, many of these probability distributions, were selected. Another important aspect of our baseline model was distinguishing our five generic user types by the specific steps of the intelligence cycle required for each. User 1 required all steps, User 2 never required exploitation, User 3 never required analysis, User 4 never required analysis or production, and User 5 never required exploitation or production. In this way we were able to approximate different hybrid TPPU architectures, considering User 1 to represent TPED.

We considered our model of the intelligence process as a steady state simulation. Therefore, before performing production runs of the IPM for this study, pilot replications were analyzed to determine an appropriate truncation point (utilizing the deletion approach to reduce initialization bias) and a sufficient replication length to reach steady state performance. See Chapter 4 of Pawling [2004] for details. Production runs for the study consisted of 25 replications with a replication length of 1580 days with the first 120 days deleted. Results are discussed for our baseline system and a system with a 50% increase in exploitation times over the baseline.

Figure 3 shows the average proportion of requirements that were met in terms of quality, timeliness, or both for our baseline configuration by priority. As would be expected with a
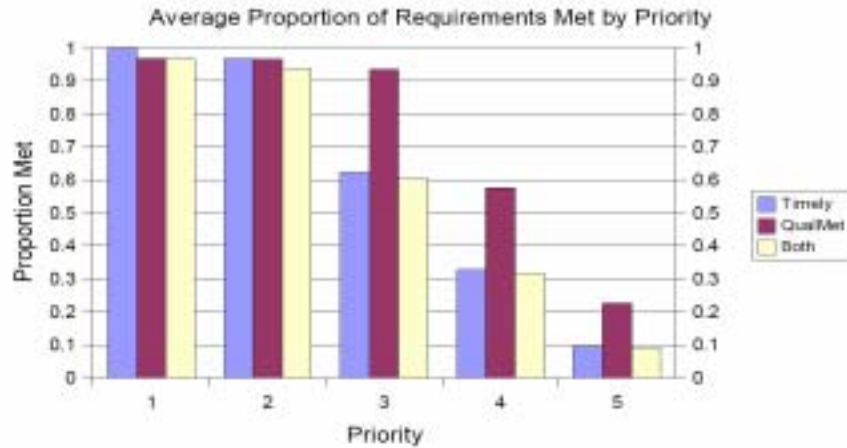
Figure 3. Baseline Average Proportion Met by Priority

priority based system, the highest priority requirements (with 1 being the highest) are on average almost always on time.   As the priority goes down, so does the proportion that meet the timeliness requirement. Figure 4 shows the average proportion of requirements that were met in terms of quality, timeliness, or both for our baseline configuration by user type. This graph shows some variation in the proportion of quality requirements met but it is fairly consistent across users. Since User 1 requires all steps it is not surprising that there is a smaller proportion of timeliness requirements met.
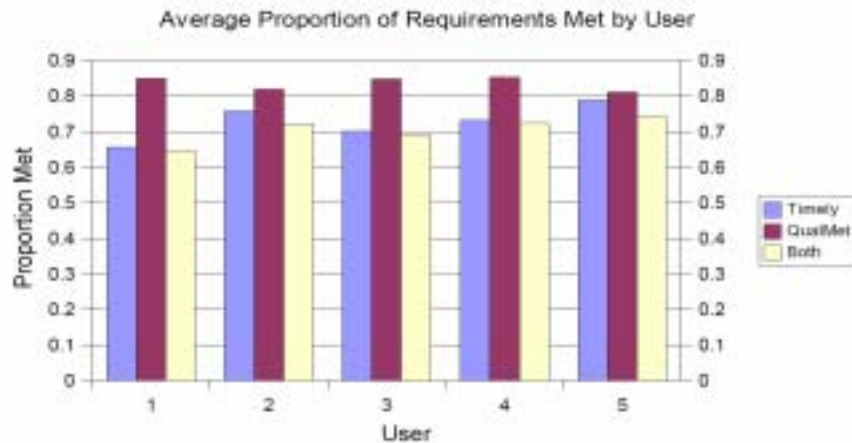
Figure 4. Baseline Average Proportion Met by User Type

In addition to our baseline model we also considered seven different cases varying different input parameters to examine various aspects of the IPM. See Pawling [2004] for more details. We include results below from our case 6 (labeled C6). This case was defined by increasing all the exploitation times by 50%. This was implemented by using a multiplicative factor of 1.5 when exploitation times were assigned in the model. Figures 5 and 6 show the proportion of both quality and timeliness requirements met by priority and user type respectively for C6 compared with the baseline (labeled BL). Figure 5 clearly shows that the system can only keep up with the top priority items for case 6. Priority 2 and 3 items have suffered a practically significant decrease in the proportion of requirements met, whereas the proportion of priority 4 and 5 items did not change significantly from the baseline. Figure 6 illustrates some significant differences with case 6 based upon the different steps of the intelligence cycle modeled for the different users. In both modeled systems Users 2 and 5 do not require exploitation except for possibly a small portion of additional requirements. This distinction explains why Users 1, 3, and 4 show a practically significant reduction in their proportion of requirements met for case 6 while Users 2 and 5 show no significant change.
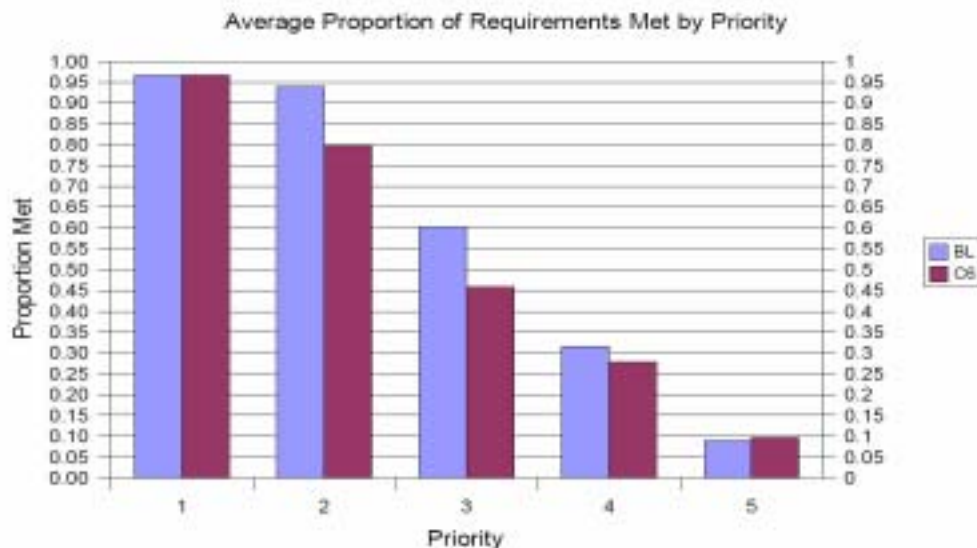

Figure 5. BL vs C6: Average Proportion Met by Priority

Conclusion

The focus of this effort was to develop a high level simulation model of the intelligence process. A review of prior efforts in modeling the intelligence process generally focused on the TPED architecture or required too much detail for a high level model. We developed the IPM from the high level perspective of the intelligence cycle presented in Joint Publications as well as subject matter expert input from U.S. national intelligence organizations. The benefit of this approach is that it is grounded on documented policy and procedures while taking a top down view of the process. The modular design of the IPM allows additional detail to be added to any particular submodel for future studies with little or no changes required for the rest of the model.

Verification and validation efforts were undertaken throughout the development of the model and included many conversations with subject matter experts and detailed walk-throughs of the IPM. The use of a notional baseline system and case studies designed to stress various aspects of the model lends additional credibility to the model given that implemented changes induced expected outcomes in the system performance. The two top areas for future enhancement to the model involve development of a more robust and realistic communications model and the incorporation of an information fusion capability.
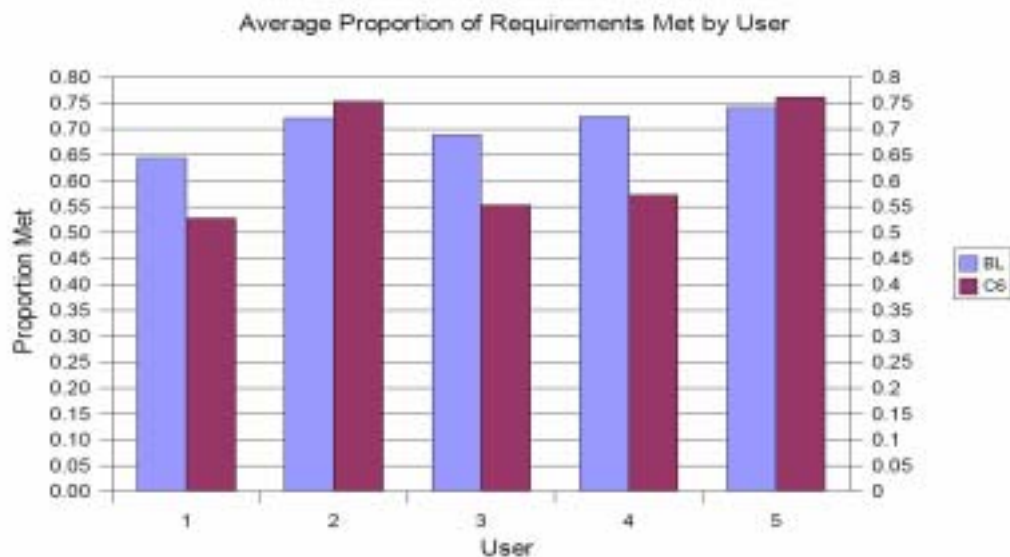
Figure 6. BL vs C6: Average Proportion Met by User Type

DISCLAIMER

The views expressed in this paper are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense or the U. S. Government.

References

Department of the Defense. *Doctrine for Intelligence Support to Joint Operations*. Joint Publication 2-0. Washington: GPO, 9 March 2000.

Kanewske, Charlie, Program Manager. *QUICM Software User's Manual*. Contract No. NRO000-98-D-2185. National Reconnaissance Office. April 2003.

Pawling, Carl R. "Modeling and Simulation of the Military Intelligence Process." MS Thesis. AFIT/GOR/ENS/04-09, Graduate School of Engineering and Management, Air Force Institute of Technology, Wright-Patterson AFB, OH. March 2004.

White House. The National Security Strategy of the United States of America. Washington: GPO, September 2002.

Air Education and Training Command

Replenishing the Combat Capability of America's Air Force

Modeling the U.S. Military Intelligence Process

Dr. J.O. Miller

Department of Operational Sciences

Air Force Institute of Technology

Capt. Carl R. Pawling

Maj. Stephen Chambal, Ph.D.

ICCRTS

Sep 2004

I n t e g r i t y - S e r v i c e - E x c e l l e n c e

Overview

- Problem Statement

- Background Information

  - Prior Work

  - Intelligence Cycle

- Intelligence Process Model

- Validation and Verification

- Analysis/Case Studies

- Conclusions

Problem Statement

- Research sponsor needs
  - Assess Tasking, Processing, Exploitation, Dissemination (TPED) and/or Tasking, Processing, Posting, Using (TPPU) processes
  - Support current and future Intelligence, Surveillance, and Reconnaissance (ISR) operations
- Develop high-level model of generalized national or military intelligence process
- Focus on basic framework for intelligence process analysis
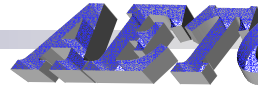
- ISR-TPED
  - Analytical simulation
  - Rigid TPED structure
  - Single detailed radar sensor model
- COSMOS (C4ISR Space and Missile Ops Simulation)
  - Highly detailed
  - Multiple engineering level sensor models
- QUICM (Quick ISR Conops Modeler)
  - High level model with multiple sources
  - TPED or TPPU but not both
  - Nearest to required capability

Intelligence Process Model

Intelligence Process Model
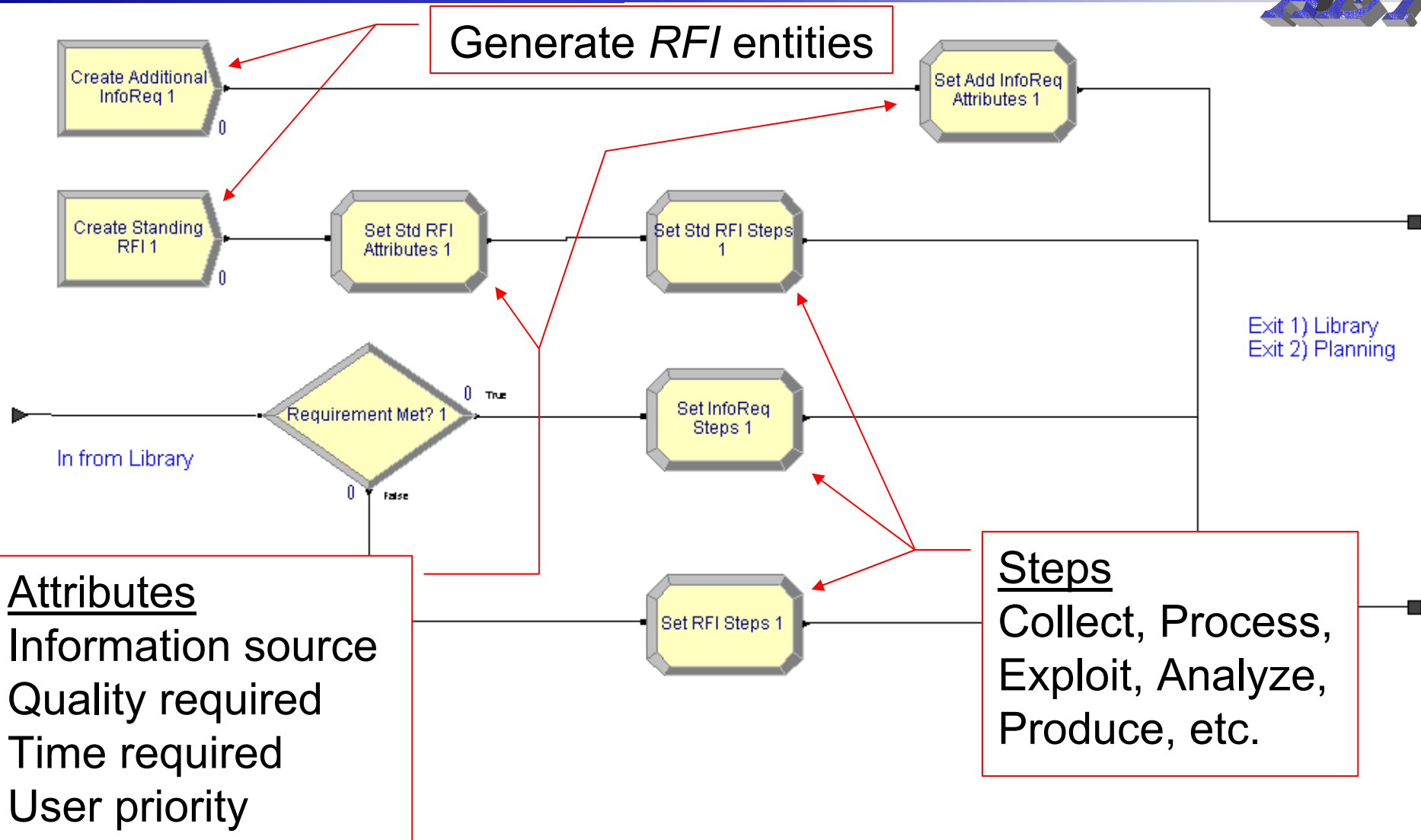
Based on the Intelligence Cycle from JP 2-0 (chapter II)

Planning and Direction
- Generate InfoReq/RFI here for users
- Set user requirements for priority, timeliness, quality, amount of processing required (e.g., TPED vs TPPU)
- Determine overall priority or order of collection based on users and their requirements
- Perform Library Search

Collection
- Task resources here to collect if required

Processing and Exploitation
- Perform processing and/or exploitation if required by user

Analysis and Production
- Perform additional analysis and production if required by users

Communications
- Contains core logic of the model
- Routes entities where they need to go next based on attributes

Dissemination and Integration
- Disseminate to users
- User Integration into processes

Evaluation
Evaluate/Record timeliness, percent of RFIs met, and other statistics

- Top-level model based on Intelligence Cycle
- Discrete Event Simulation
- Flexibility in modular design
- Easily expandable

IPM – User 1 Planning

Generate *RFI* entities

Create Additional InfoReq 1 — 0

Set Add InfoReq Attributes 1

Create Standing RFI 1 — 0

Set Std RFI Attributes 1

Set Std RFI Steps 1

Requirement Met? 1 — 0 True / 0 False

In from Library

Set InfoReq Steps 1

Exit 1) Library
Exit 2) Planning

Set RFI Steps 1

Attributes
Information source
Quality required
Time required
User priority

Steps
Collect, Process, Exploit, Analyze, Produce, etc.

- 5 user modules represent beginning of process

- Model *RFI*s analogous to a tracking sheet for real RFIs

IPM – Collection
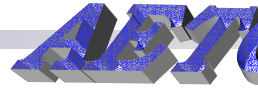
$$(TNOW - Entity.CreateTime) - TimeR <= Timely\_Threshold$$

Enter Collection → Collect Data → Timely for Collection? (0 True) → Collection Delay → Determine Quality Achieved → Release Sources 2 → Assign CollectionStation Variable 2 → Leave Collection

(0 False) → Release Sources 1 → Assign CollectionStation Variable 1 → Leave Collection to Evaluation

Although untimely items grab the resource, that resource is released after a 0 time delay, effectively not using the resource.

*This should not affect time weighted statistics, but would affect discrete statistics such as numer of times a resource was used.

- Highest priority *RFI*s processed first
- Only processed when appropriate source is available
- Timeliness check avoids using resources on untimely *RFI*s
- Expression arrays based on source and required quality determine delay and achieved quality
- Similar structure in other submodels

IPM - Communications
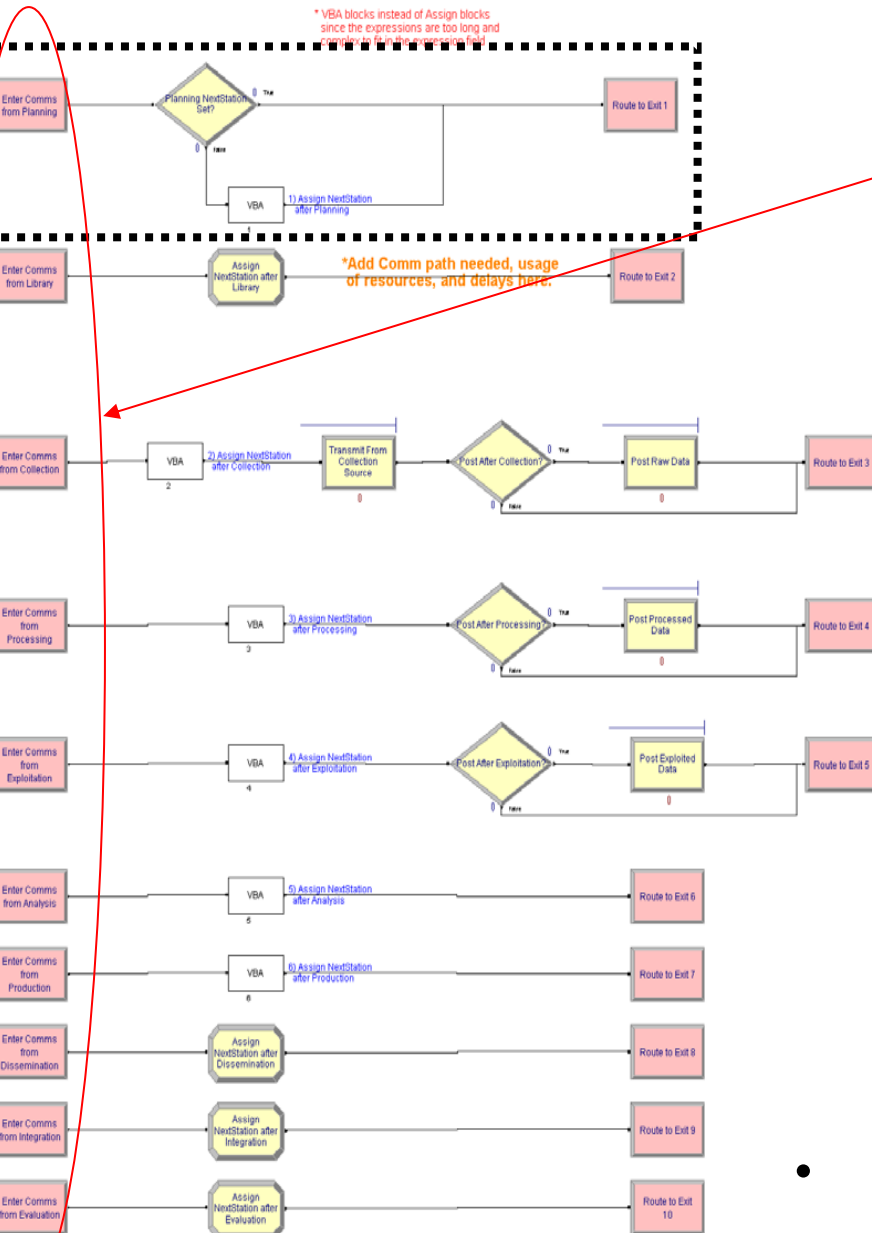
Entry and exit for each submodel
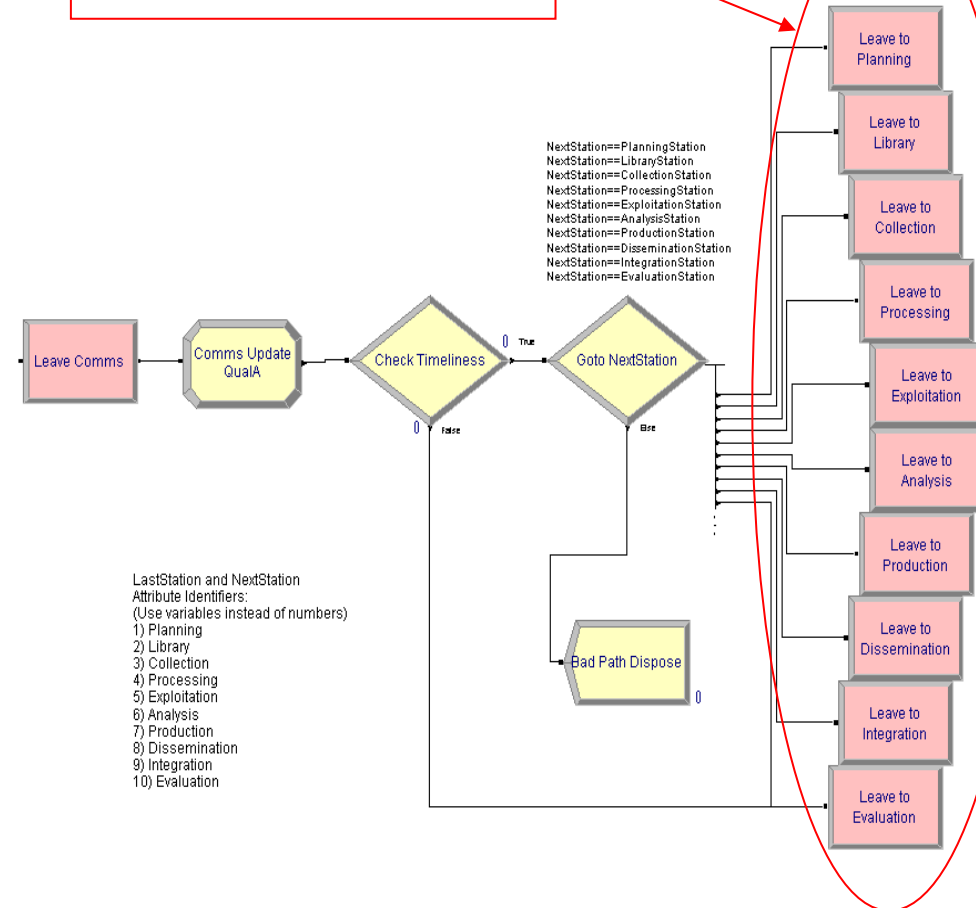
* Contains the core logic for *RFI* routing
* Provides framework for updates if needed

IPM - Communications
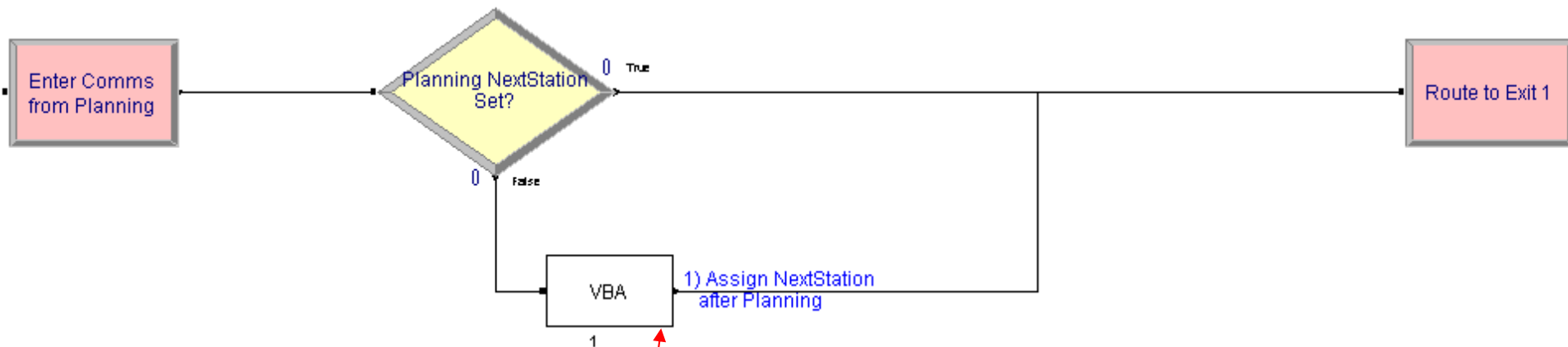

```
' Determine NextStation after Planning
If Need_Collect = 1 Then
    Next_Station = Stn_Collection
ElseIf Need_Process = 1 Then
    Next_Station = Stn_Processing
ElseIf Need_Exploit = 1 Then
    Next_Station = Stn_Exploitation
ElseIf Need_Analyze = 1 Then
    Next_Station = Stn_Analysis
ElseIf Need_Produce = 1 Then
    Next_Station = Stn_Production
ElseIf Need_Disseminate = 1 Then
    Next_Station = Stn_Dissemination
ElseIf Need_Integrate = 1 Then
    Next_Station = Stn_Integration
Else
    Next_Station = Stn_Evaluation
End If
```

- Determine where *RFI*s should go next based on steps needed and last step completed
- VBA routing logic
  - Adds flexibility
  - Simplifies structure
  - Central location for updates

Data Request Sheet

NumUsers — Number of users for the study. This affects all arrays below with an User dimension.

	Value	Max
NumUsers	5	5

NumInfoSources — Number of information sources for the study. This affects all arrays below with an InfoSource dimension.

	Value	Max
NumInfoSources	4	13

NumAnalystSpecialties — Number of specialties for all source analysts. This affects all arrays below with an AnalystSpecialty dimension.

	Value	Max
NumAnalystSpecialties	4	13

**Note: If the values above are less than their max values, the remaing items in an array can be set to 0 (zero).
**Note: Some Sample entries have been given
**Note: Additional Variables or Expressions can be defined and used to fill out the datasheet if desired. Please add these items and defintions to the bottom of the sheet.

InfoCollectTimes — Each entry of the array corresponds to the distribution of time taken to collect information from a specified information source at a specified level of required quality.

InfoSource

QualR	1	2	3	4	5	6	7	8	9	10	11	12
1	EXPO(3,1)	3	UNIF(0.8,1.6,3)	EXPO(0.3,4)	0	0	0	0	0	0	0	0
2	EXPO(4,1)	4	UNIF(0.8,1.6,3)	EXPO(0.6,4)	0	0	0	0	0	0	0	0
3	EXPO(5,1)	5	UNIF(0.8,1.6,3)	EXPO(0.9,4)	0	0	0	0	0	0	0	0
4	EXPO(6,1)	6	UNIF(1.6,3.2,3)	EXPO(1.2,4)	0	0	0	0	0	0	0	0
5	EXPO(7,1)	7	UNIF(1.6,3.2,3)	EXPO(1.5,4)	0	0	0	0	0	0	0	0

LibrarySearchTimes — Each entry of the array corresponds to the distribution of time taken to search the "Library" of information available for information from a specified information source and level of required quality.

InfoSource

QualR	1	2	3	4	5	6	7	8	9	10	11	12
1	EXPO(0.08,1)	EXPO(0.08,2)	EXPO(0.08,3)	EXPO(0.08,4)	0	0	0	0	0	0	0	0
2	EXPO(0.1,1)	EXPO(0.1,2)	EXPO(0.1,3)	EXPO(0.1,4)	0	0	0	0	0	0	0	0
3	EXPO(0.12,1)	EXPO(0.12,2)	EXPO(0.12,3)	EXPO(0.12,4)	0	0	0	0	0	0	0	0
4	EXPO(0.14,1)	EXPO(0.14,2)	EXPO(0.14,3)	EXPO(0.14,4)	0	0	0	0	0	0	0	0
5	EXPO(0.16,1)	EXPO(0.16,2)	EXPO(0.16,3)	EXPO(0.16,4)	0	0	0	0	0	0	0	0

- One location for data collection and annotation
- Arrays easily transferred into Arena
- Flexibility for scenario customization without model framework modification
  - Over 2700 possible inputs (about 830 used for case studies)
  - Distributions, expressions, variables, resources, etc.

Validation and Verification

- Multiple SME reviews
- Detailed model walk-throughs
- Arena animation
- Review of output statistics
- Analysis of sample case studies
  - Notional data
  - Examine general model performance and trends
  - Not predicting or assessing actual system performance

Case Studies

- Stress IPM simulation with simple changes
- Baseline (BL): Notional data
- Cases selected to evaluate model framework
  - C1: *Timely_Threshold* = 48 hours
  - C2: *Timely_Threshold* = 12 hours
  - C3: *QualMet_Threshold* = 3
  - C4: *QualMet_Threshold* = 1
  - C5: Increase additional requirements by 50%
  - **C6: Increase exploitation times by 50%**
  - C7: Increase analysis times by 50%

- For any *RFI* that needed collection, users required different steps to meet their needs
- User 1: All steps
- User 2: No exploitation
- User 3: No analysis
- User 4: Neither analysis nor production
- User 5: Neither exploitation nor production

Replication Parameters
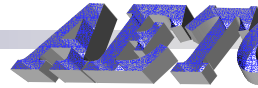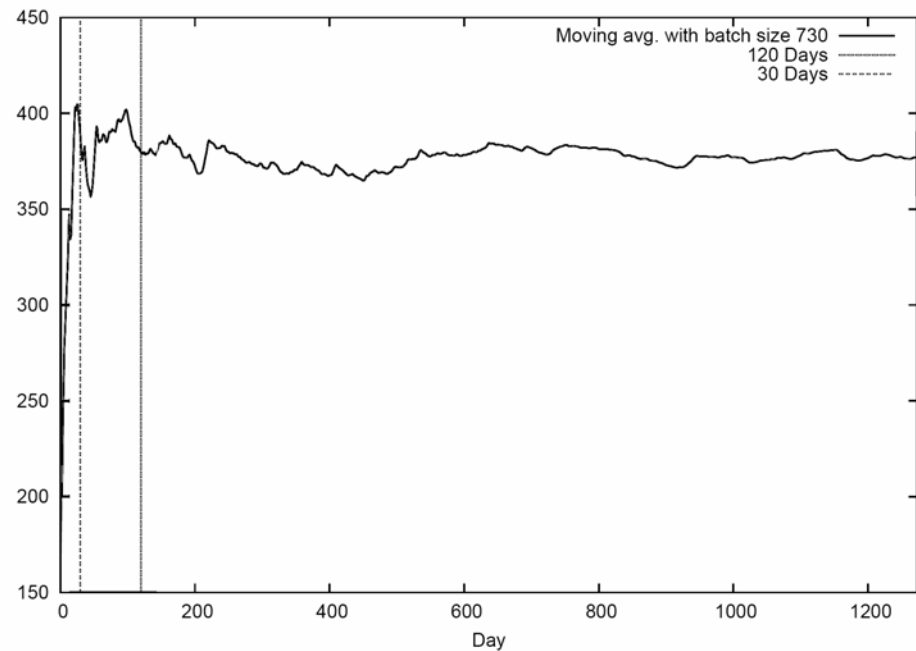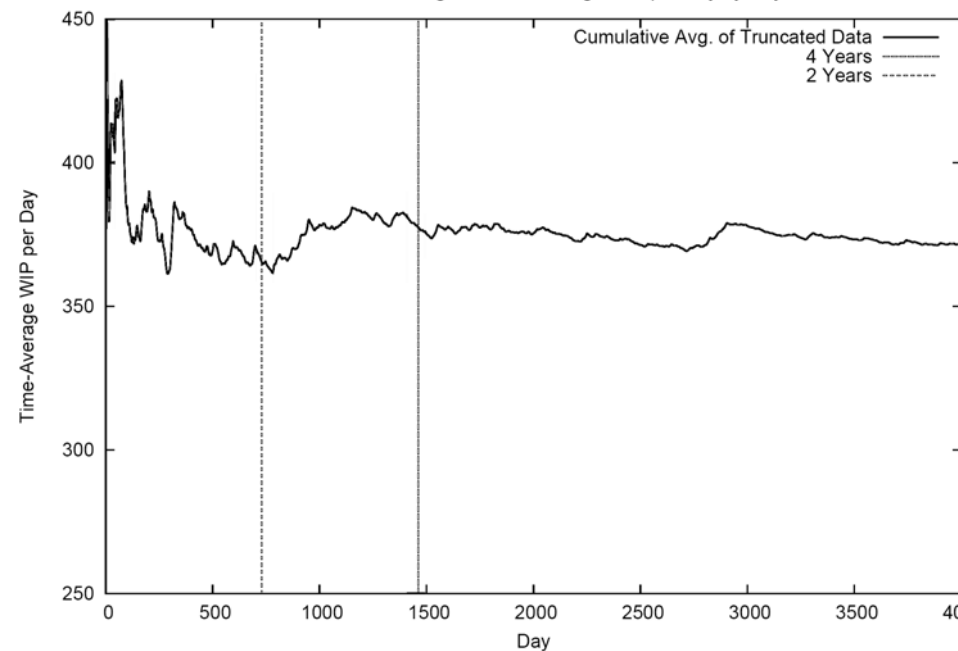
- Goal: reduced bias and variation of simulation output
- Examined single long replication of baseline system
- Total work in process (plotted above) and total time in system
- Truncate to reduce bias, then terminate near steady state
- Multiple replications

Simulation Outputs

- Standard process simulation measures (total wait time, total time in system, work in process, number in queues, resource utilization, etc.)

- Proportion of timely, quality, and both requirements met partitioned by priority, source, user, type

- Total wait time by priority

- Many additional statistics can be easily added

Simulation Results - BL
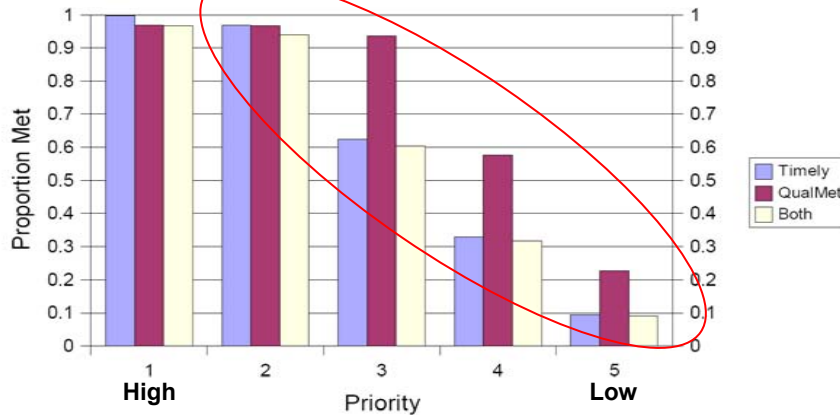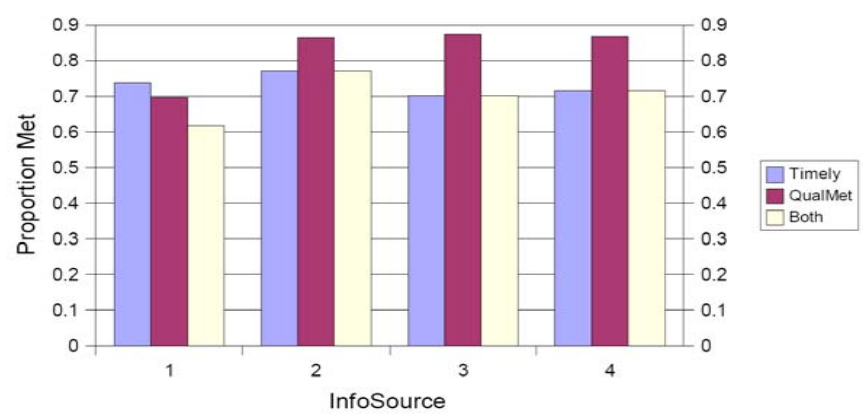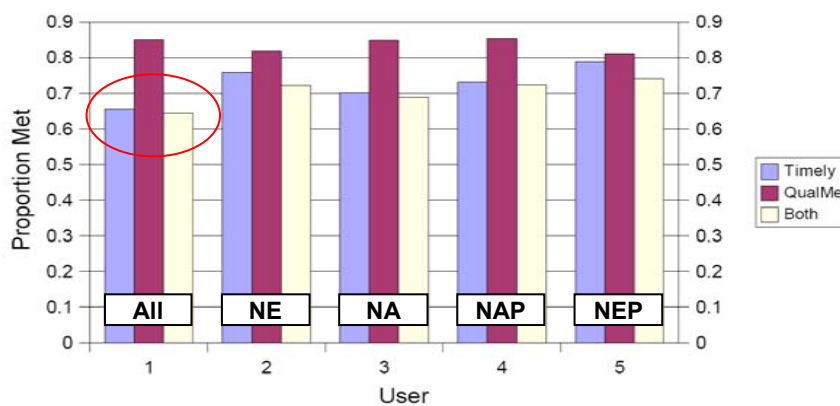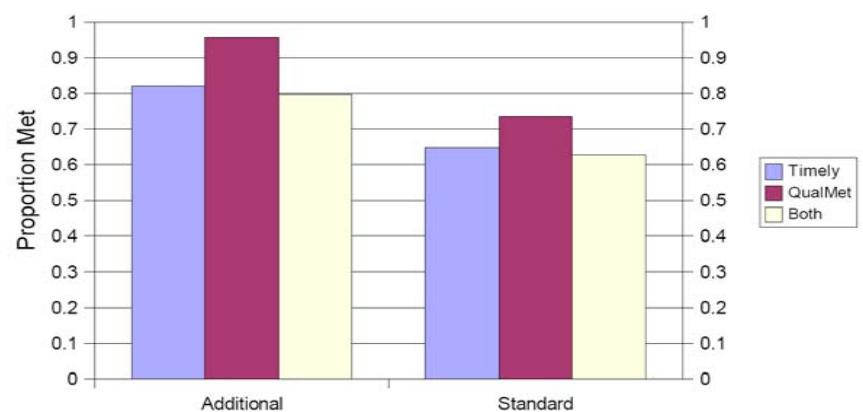
- Baseline system
- Proportion of requirements met for timely, quality, both
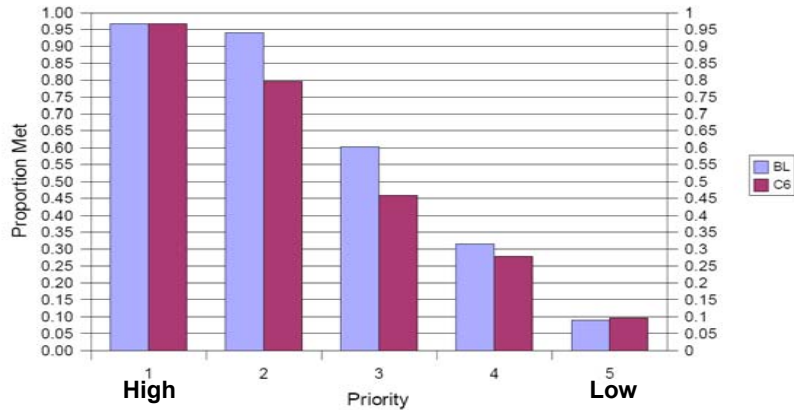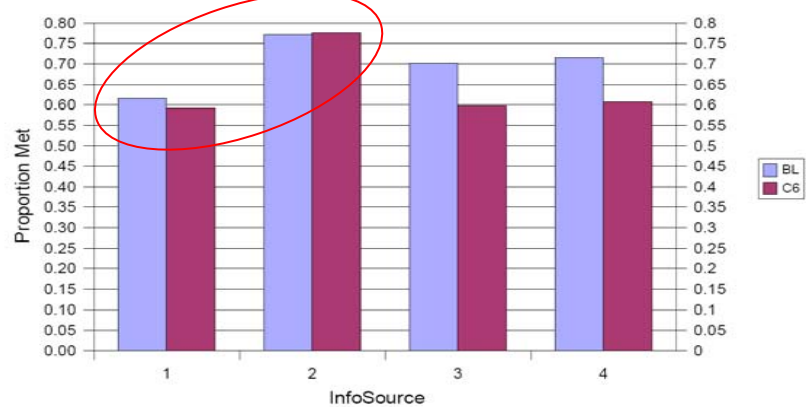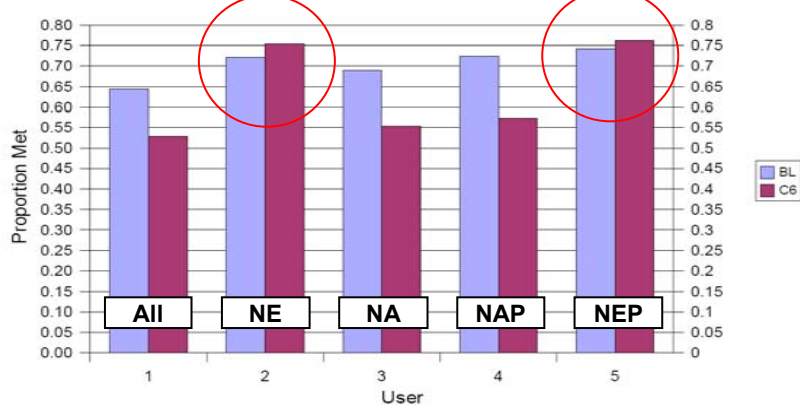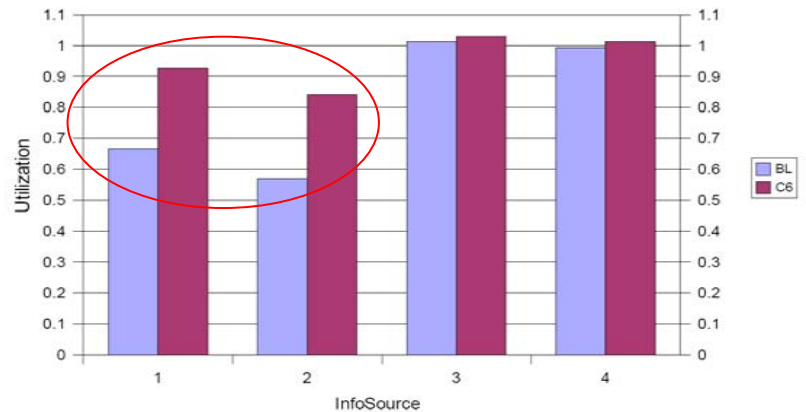
- C6: Increase exploitation times by 50%

Conclusions

- Flexibility
  - High level model developed from top down perspective
  - Modular framework
  - Centralized arrays of inputs
    - Customize without modifying framework
    - Aid input verification
  - Not restricted to any specific platform or traditional intelligence disciplines
- Credibility
  - Grounded on documented process
  - Validation and verification effort
  - Case study results

Conclusions
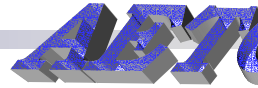
- Application
  - TPED/TPPU comparisons in a hybrid system
  - Impact of proposed changes to the system
- Future Research
  - Additional *Communications* submodel detail
  - Information Integration/Fusion

Replenishing the Combat Capability of America's Air Force

AIR EDUCATION & TRAINING COMMAND

Integrity - Service - Excellence

Sample of Paired-t Tests

alpha = 0.05

*Insignificant differences **highlighted** based on alpha*

Paired-t test p-values for User 1 vs User 5 over 25 replications

Case	Timely	QualMet	Both
BL	0.00000000	0.00000000	0.00000000
C1	0.00000000	0.00000000	0.00000000
C2	0.00000000	0.00000000	0.00000000
C3	0.00000000	*0.68767872*	0.00000000
C4	0.00000000	*0.56661909*	0.00000000
C5	0.00000000	0.00000000	0.00000000
C6	0.00000000	0.00000000	0.00000000
C7	0.00000000	0.00000000	0.00000000

mean diff = -0.000112

mean diff = -0.000389

Paired-t test p-values Case comparisons for User 1 over 25 reps

	Timely	QualMet	Both
BL – C1	0.00000000	0.00000000	0.00000000
BL – C2	0.00000000	0.00099752	0.00000000
BL – C3	0.00226316	0.00000000	0.00000000
BL – C4	*0.49213783*	0.00000000	0.00000004
BL – C5	0.00000000	0.00000000	0.00000000
BL – C6	0.00000000	0.00000007	0.00000000
BL – C7	0.00000000	*0.61116139*	0.00000000
C1 – C2	0.00000000	0.00001316	0.00000000
C3 – C4	0.00428745	0.00000000	0.00421697

mean diff = 0.000898

mean diff = -0.000452

Paired-t test p-values Case comparisons for User 5 over 25 reps

	Timely	QualMet	Both
BL – C1	0.00000000	0.00000000	0.00000000
BL – C2	0.00055935	0.00000913	0.00513163
BL – C3	0.00682321	0.00000000	0.00000000
BL – C4	*0.70841705*	0.00000000	0.00000000
BL – C5	0.00000000	0.00000000	0.00000000
BL – C6	0.00000000	*0.12096061*	0.00000000
BL – C7	0.00000000	0.00000007	0.00000000
C1 – C2	0.00000000	0.00008434	0.00000007
C3 – C4	0.03908054	0.00000000	0.03849555

mean diff = -0.000501

mean diff = -0.001241

mean diff = 0.003313